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# DEFINING THE CONVECTIVE DRIVING FORCE FOR SOIL GAS INTRUSION INTO HOUSES

## Research Question

The practice of applying site specific risk assessment (SSRA) procedures when dealing with the re-development of hazardous lands has grown significantly. Much of this interest in SSRA is a result of very strict generic environmental quality guidelines for soil and groundwater. The problem is that many of the published guidelines are so low that the cost of achieving the required clean-up levels are in many cases cost-prohibitive. However in the application of SSRA procedures, specific site characteristics can be incorporated in the decision making. In such cases, investigators are faced with the decision of determining what residual contaminant levels could remain in the subsurface below which the associated health effect is deemed negligible. Negligible effects are typically realized when insufficient concentrations are present, the exposure pathway is not well developed, or exposure duration is limited.

One exposure pathway which can have an influence on the outcome of an SSRA when volatile contaminants compounds are involved is the leakage of contaminated subsurface gases into the indoor air environment. Evaluation of this pathway currently is mostly completed with the use of mathematical models. The current level of understanding is that both convective and diffusive contaminant transport processes in the soil and across the subsurface building envelope will contribute to degraded indoor air quality. Convective transport of contaminants by far creates greater impacts to the indoor air quality.

The modelling of soil gas entry has for the most part has been achieved through radon-entry models and modifications to the code. One popular model which is used for site specific risk assessment purposes has been published by Johnson and Ettinger (1991). In situations where convective processes dominate and large cross-envelope pressures occur, impacts to the indoor air environment can be very significant. Such situations can be simulated mathematically by using a large pressure differential (>>1 Pa) across the basement envelope for example in the Johnson and Ettinger model.

Because the cross-envelope pressure has such a significant affect on soil gas entry, better definition of this parameter was required for several reasons.

- There was uncertainty in the literature regarding the magnitude of the differential pressures which could develop.
- The magnitude of the differential pressure in our opinion should be related to specific geologic settings. Recent soil gas entry literature does not make this connection.
- The documentation of cross-envelope pressures may be useful as an indicator of flow direction in testing situations.

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## Methods

To evaluate the impact of soil gas pressures due to different subsurface geology/surface structures, three different types of sites were investigated.

- the stratigraphy consisted of a low permeability soil overlying a higher permeability soil (2 sites),
- the stratigraphy consisted of mostly of sandy conditions from surface to the building foundations (2 sites),
- the stratigraphy consisted of a mixture of till and sand (1 site).

## Findings

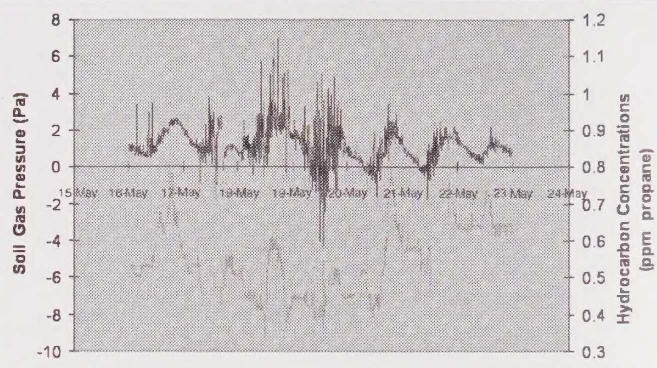
Several observations were found during the field portion of this study.

1. In those cases where a homogeneous soil stratum existed from ground surface to the basement footings, low cross-envelope pressures generally developed. Data generally suggested that pressures in the range of less than 5 Pa were common. The results of three of the houses with generally uniform subsurface geology showed very little deviation from the modelling assumptions and conclusions reached with the traditional modelling approaches such as Johnson and Etinger.
2. Sites where the subsurface could be defined by several geological layers of varying permeabilities, cross-envelope pressures ranged from 20 to 50 Pa during periods of rapid atmospheric pressure decline.
3. Although it was conjectured that surface coverings such as asphalt or concrete could potentially have similar impacts on soil gas pressures as did the lower permeability layers, this study did not identify any cases where this was the case.

The documentation of soil gas pressures also was found to be useful for determining times for soil gas entry. The graph below shows a example of one site where the indoor hydrocarbon levels (as recorded by a FID hydrocarbon analyzer) were found to correlate with the soil gas pressures. The recording of soil gas pressures could therefore be used to define times when soil gases should be present in the indoor environment.

In the final phase of the project, modelling of the soil gas pressures and degree of soil gas influx was undertaken.

### Figure 1: Indoor Hydrocarbon Levels and Soil Gas Pressures




Because there is a significant literature database for the modelling of homogeneous subsurface geologic environments, work on such scenarios would not provide substantial advances. Instead, modelling situations where low permeability layers overlie geological formations of higher permeabilities would be more beneficial to the science.

The conceptual basis for the modelling effort had its origins in the remediation science of soil gas vacuum extraction (SVE) systems. The model was calibrated to the pressures as recorded at one of the sites. Although the house did not have characteristics which would lend itself to very significant indoor air quality problems, the model was able to generate a realistic value of soil gas leakage rate, a number which is often very difficult to produce even in the most ideal situations.

The modelling effort was then used to evaluate the effect of a confining layer in the vicinity of the house. From this work, it was apparent that the presence of a confining layer was critical in the development of cross-envelop pressures. Without the confining layer present, the cross-envelope pressure would be much less. Hence the contaminant transfer indoors would also be restricted. Therefore if houses had geologic settings where elevated subsurface pressures could potentially develop, a strategy of puncturing the confining layer to cause subsurface depressurization would be recommended.

The modelling effort undertaken here was a start for such an analysis. Future work in using a model such as this at a "hazardous" site where variable geologic conditions existed would be helpful. More work with this model in a real contaminant situation would allow for the refinement of the techniques used and more accurate calibration.

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